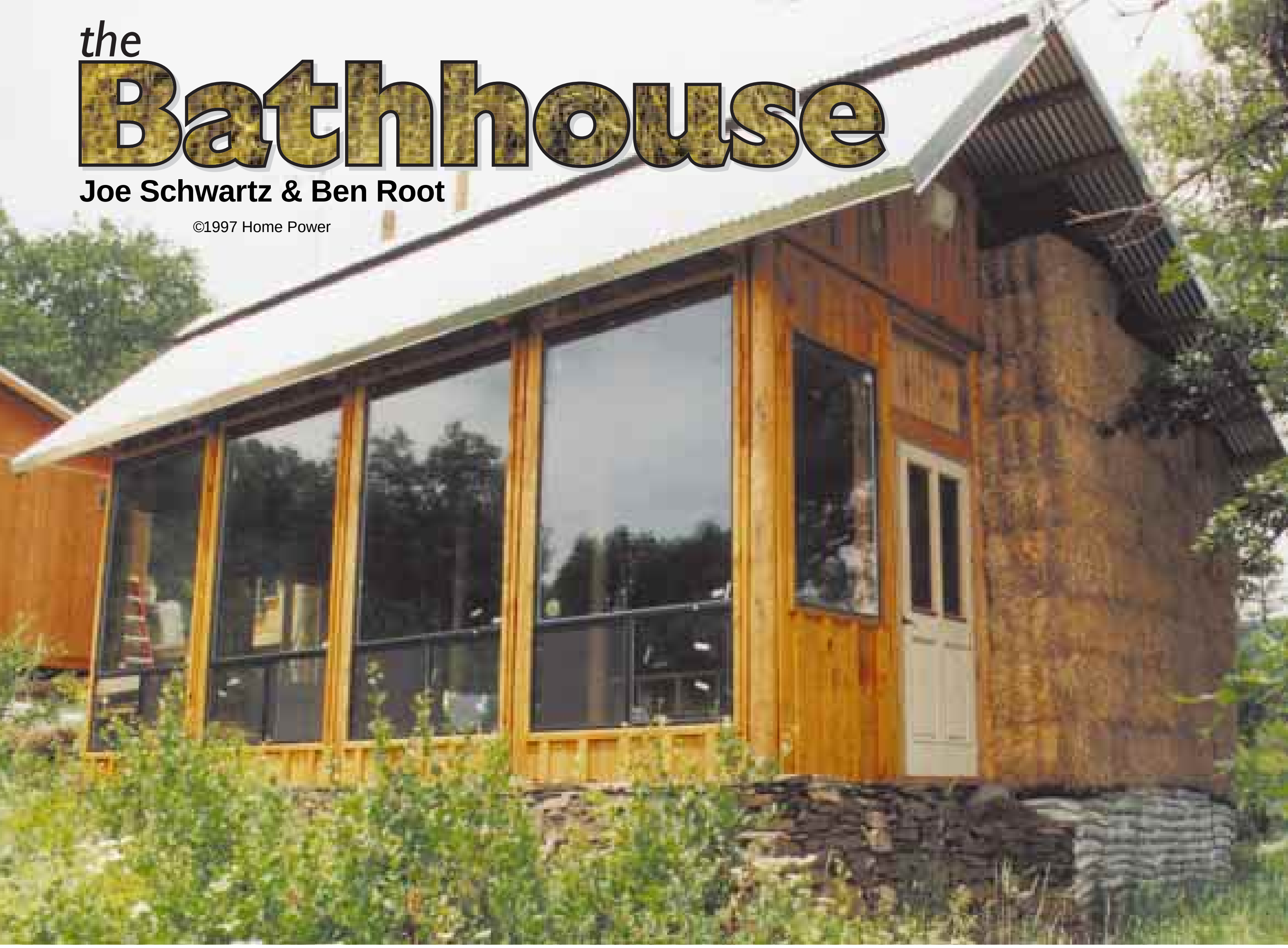
the Bathhouse

Joe Schwartz & Ben Root



The spring was the deciding factor when we bought our homestead on Agate Flat in 1970. A good supply of clean, reliable water is an essential ingredient in any homestead. We hauled water, by hand, over one thousand feet from the spring to our cabin. A standard load was two, five gallon jerry cans. We had no hot water heater, shower, bath, dish washer, clothes washer, or even a cold water faucet over the kitchen sink. We were happy with the two to four, five gallon jerry cans of water we hauled daily. The water was pure, on site, and ours. Hauling the eighty-plus pounds an 1/8 of a mile was exercise. We were happy to expend the effort if it meant we got to live on Agate Flat instead of in the city.

Over the years our water demands and expectations grew. We added gardens and various animals (cats, dogs, pigs, turkeys, cows, chickens, goats, horses, and mules) to our homestead—all of them wanted watering daily. During that over twenty year period, I calculate we hauled, by hand, over 1,200,000 pounds of water. Eventually, in 1992 we drilled a well, added a 5 gpm solar-powered pumping system, and storage tanks for 2,700 gallons of well water. This well water now gravity flows to our buildings, stock tank, and gardens.

By the fall of 1996, we were ready to tackle obtaining the conveniences most Americans take for granted—hot showers and a clothes washer. We needed a building to house these systems, and the composting toilet to end over twenty-five years of outhouse use. Karen, being Karen, saw no reason not to have a small greenhouse as well. To complicate matters, Agate Flat is not a wimpy environment. We get four distinct seasons, from fry-your-butt in bone dry summers, to freeze-your-butt in four feet of snow winters.

Enter Ben Root (the designer) and Joe Schwartz (the builder). We all wanted to minimise the use of energy intensive building materials, fossil-fueled excavation machines, and anything which cost too much money. We asked them to design and build an energy efficient building—a home for our solar showers, Karen's herb garden, and our PV-powered clean clothes machine. Here is what they have accomplished…. Richard Perez

Funky Mountain Institute is a study in dualities. Plywood cabins house high-tech computers. The electronics bench is in the living room. The extensive electrical power system operates flawlessly yet bathing is a bit of an adventure. Bucket bathes are effective, even romantic, but take bravery in the winter time.

Above: Working our way up, post and beam on concrete piers.

Below: Face it south!
Getting our solar orientation right.

Defining needs

At the time of writing, it has been just over a year since we broke ground on a project to create a centralized water use facility, i.e. a bathroom, here at Agate Flat. The initial goal of the project was to provide facilities for efficient and pleasurable bathing. From there stemmed the desire for an indoor (composting) toilet and a clothes washer. Being RE nerds, we wanted the building to also act as a test bed for various solar hot water technologies.

The initial sketches were of a simple, modular, stick-framed structure. Cheap and dirty. Quickly the project grew. Winter time bathing required a space that could be heated; that means insulation. The list of appliances grew too, pushing the plans to expansive multi-story structures. Greenhouse space was mentioned. Things got complex and expensive. We backed up, trying to simplify our needs. But as each element was added we said "Well, if we're gonna do X, why not do it right and add Y?" the project grew again. And again we backed up.

In the renewable energy tradition, we felt that the building should be energy efficient, and as low an impact on the environment as possible. Alternative building techniques seemed attractive, but fears of unproven technologies and our own unfamiliarity made us hesitate. Slowly, as Ben ran computer drawings back and forth between Karen and Richard (as clients) and Joe (as builder) a plan came together.

Puzzle Pieces

Prior to any construction related decisions, certain pieces of the project were pre-defined. A long list of appliances had to fit, function, and interact with each other and the HP crew. An insulated shower stall built by Larry Schusler at Sun Frost awaits testing. An old enamel tub and sink were pulled off the junk pile and designed in. The tub would provide a luxurious soaking experience once nestled among the trellaced plants and garden beds. The Staber washing machine will take a huge time-consuming chore out of Karen's already too hectic trips to town.

The hot water system itself will be expansive. A propane tank-style water heater act as back-up and is last in line before the hot water loads. Ahead of that lies two pre-heat tanks, each supporting a separate solar hot water system. The goal is to provide flexible configurations for solar water system

Above: Dirt bag retaining wall/footing along north wall and under future bathing deck.

Below right: The north-east corner showing dirtbags and strawbale wall.

tea kettle within reach of the bathtub. In the future this may be replaced with a more efficient stove with a hot water loop.

The biggest and surely the most challenging appliance to incorporate into the building design was the composting toilet by Advanced Composting. The tank is capable of ten full time users and stands thirteen feet tall. This two story appliance was a real sticking point in keeping the building design simple. The "Tower of Turd" allows access to the toilet, via deck, from nearly the same elevation as the house. Located on the north-west corner of the building it became a creative and fun element in the final building design. Thanks to Richard and Karen for accepting our funky solution.

These appliances were fit together like puzzle pieces. We wanted to keep the building small and the plumbing centralized, but things had to function. The trick was to arrange these components in a layout around which an efficient building could be built.

Materials

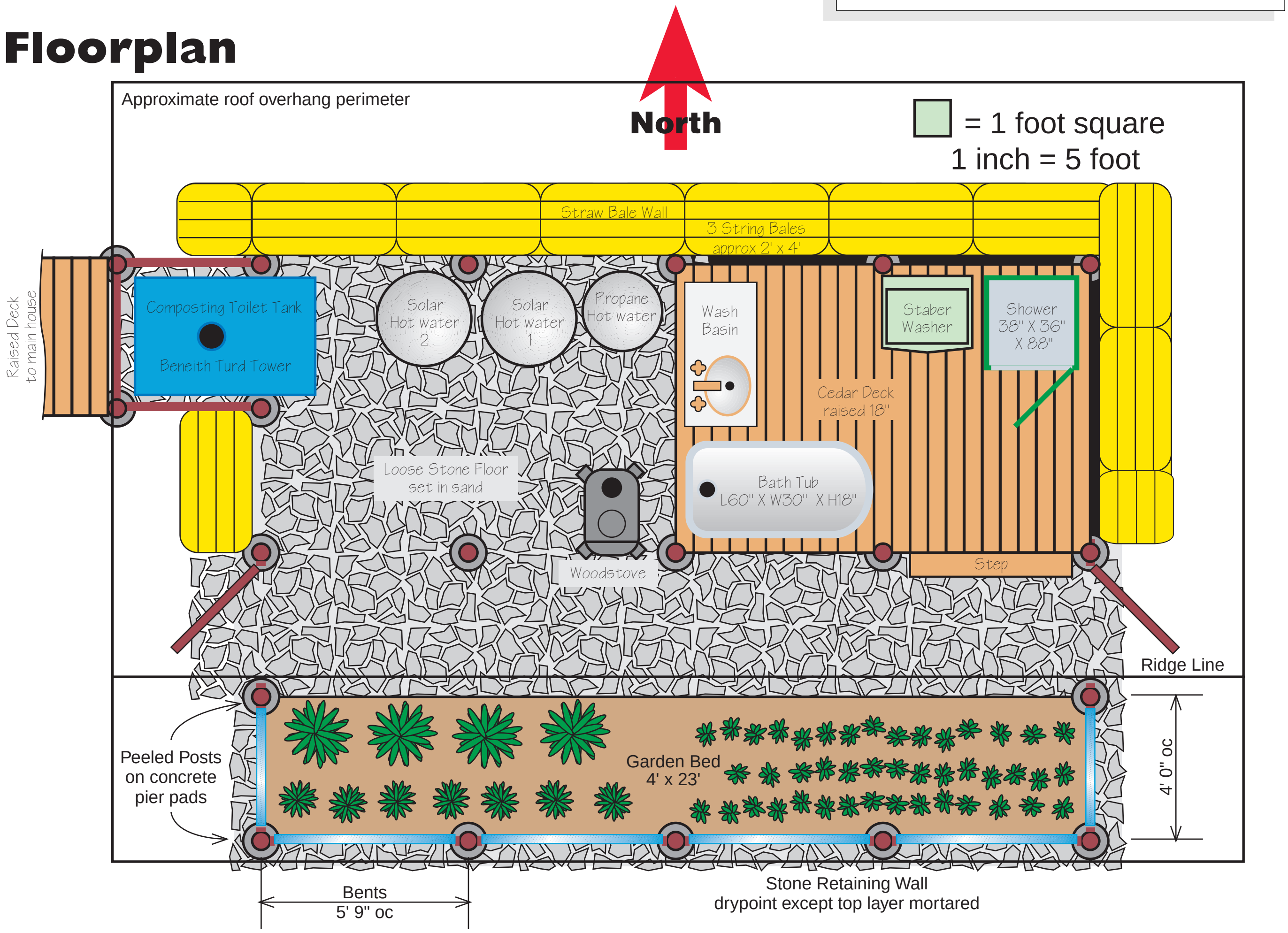
Once the desired appliances were sorted out, we began to ponder the building itself and the materials required to build it. Our choices of building materials were based on two main theories. 1 Save energy. 2 Save money. We figured that we could accomplish both by using materials low on the consumer chain.

First we looked for local materials indigenous to Agate Flat. The mud here is great (unless you're trying to drive through it) and stone is everywhere. Building with on-site resources makes good sense, just ask the indigenous peoples of the world. The materials are free, accessible, and create structures that compliment the local landscape.

testing. The best performing unit will stay at Agate Flat. Challengers will come and go. The system will allow any combination of series or parallel arrangements of the three hot water sources, and the ability to work on any part of the system without taking the rest of the system down. Plumbing will all be exposed and accessible, "submarine style" as Richard likes to say. Look for a complete discussion of the hot water system in a future article.

For now an old cast iron wood stove will provide back up heat. The cute, but rusty little unit, from Karen and Richard's original cabin, means a

Floorplan



We also scouted for recycled materials. Salvage means spreading out the embodied energy, and cost, of a product over a longer period of time. Second hand can be hit or miss, so start in advance. You'll find materials with character as well as save money. Besides, what a perfect excuse to go yard saling. When we did buy new, we attempted to use materials that were as unprocessed as possible. The energy saved was evident by the money saved.

Glass

Passive solar heating was a must-have for us solar bozos. The 16 foot by 24 foot building is layed out long on the east-west axis providing a large south wall for solar gain. Good windows were on top of the wish list. We found a window manufacturer that had four blemished, five foot by eight foot, double pane, low E, operable windows. For the whopping price tag of 80 bucks each they were about 10-15% of what they would have cost new. Garden space is one of the major focuses of the structure so we opted to glaze about 90% of the south wall to gain maximum sunlight for plant growth. In a living space this would be excessive glazing area. (See the side bar on the basic elements of Passive Solar Design.) For a green house and bath house, with wider acceptable temperature fluctuations, we felt it appropriate. With properly designed overhangs, overheating can be eliminated. The noon sun on the summer solstice barely enters the garden bed. On the winter solstice, however, the lower noon sun reaches 16 feet to the base of the north wall. This means solar thermal gain when it's needed most. A draw-back to this much glazing is excessive heat loss at night. Even efficient windows with an R value of 3 or 4 are basically, from an insulative standpoint, huge holes in the wall. Eventually, operable window quilts will be installed to lessen nighttime heat loss.

Stone

A six inch deep floor of paving stones serves as the building's thermal mass. Flat stones gathered from the property are set loose in sand; this means no concrete and great drainage. High mass is needed to balance the daily thermal fluctuations created by the large glazing area. Local stones were also used for the south retaining wall. Set without mortar, except for the cap layer, they create a natural transition from the landscape to the building.

Straw

Now we are efficiently gathering solar energy through the glazing and storing it as heat in the building's mass. To keep the heat in during the cold season and nights

The Basic Elements of Passive Solar Design

Effectively heating a home or other space with solar energy is a balance of many variables. Even the simplest technique, direct gain, takes planning to avoid the possible pitfalls. Here are the five main elements to consider when designing a direct gain solar house.

1 Siting & Orientation

The building should be positioned where it will receive winter sun from 9:00 am until 3:00 pm (90% of the suns daily energy). Orient the building south (beware of magnetic declination for your site) to capture available radiation. Variations up to 25° east or west of true south will still provide 90% of the sun's energy throughout the day, so some positioning to maximize view is OK. Position rooms within the building to efficiently use the suns heat: living spaces on the south, garage and utility rooms on the north.

2 Glazing

Windows allow the sun's energy in to heat your house (direct gain). Larger windows should be positioned on the south wall to maximize efficiency. Window area of 0.19 to 0.38 square feet per square foot of floor area is recommended for cold climates. In contrast, the north wall should have very few, and small, windows to prevent heat loss. East and west windows may be of moderate size but low sun angles here can create over-bright conditions, and unwanted solar gain in the summer months.

3 Overhangs

Eves or awnings are important on south-facing windows to limit the amount of sunlight transmitted in summertime. Too much summer sun will cause overheating of the space. An overhang of 1/4 of the window height in southern latitudes (39°), up to 1/2 of the window height in northern latitudes (48°) will prevent excessive summer sun from entering. Lower winter sun will still be able to enter to warm the space. Overhangs are not as effective on east and west windows due to low sun angles.

4 Thermal Mass

Mass is often the most important yet misunderstood element in a successful solar home. Appropriate mass, (e.g. concrete floor, adobe walls, masonry stove, etc.) acts as a thermal battery, collecting the sun's energy which shines on it during the day. This heat then dissipates slowly back into the living space overnight or through cloudy periods. Too little mass and your house temperatures will fluctuate daily, and seasonally. Sufficient mass will level out a buildings temperatures like a warm rock in the sun during winter, and a cool rock in the shade during summer.

It is possible to have too much mass, causing your building to never reach a comfortable temperature during the hours of sun, but this is more often the exception.

5 Insulation

Insulation (or more appropriately "Outsulation") is the compliment to mass. By enclosing the outside of the structure with a barrier against heat transmission, heat is kept inside where it's needed. Insulation does not store heat but merely prevents it from escaping.

These elements need to be balanced for each specific application and within each element lies many variables, but the potential for free, comfortable, and non-polluting space-heating is worth doing the homework.

means insulation. Quick to build, strawbale walls seemed to be an obvious choice. The material has an R value of 40 to 50, more than twice the insulative value required for walls in most states. Straw is non-toxic, harvested annually, and is largely considered a waste product by agri-business. Much of this resource is burned in the field to make way for the next planting. The results are diminished nutrient levels in the soil and increased air pollution. No thanks, how about an inexpensive and efficient building material instead?

Our one hesitation in using strawbales was due to the activities that would take place inside the building; baths, showers, and garden watering. We knew we could eliminate potential outdoor moisture problems with proper drainage, good footings, and big roof overhangs. However, indoor humidity is guaranteed to be high creating a difficult environment for the bales. We will be installing a system to monitor temperature and humidity at several locations within the bale walls and throughout the building. Logging of the sensor's output data will enable us to analyze both strawbale and overall building performance.

Dirtbags

Many successful structures have been built using strawbale walls to support the roof. However, we decided on non-loadbearing strawbale walls. We wanted to minimize our use of concrete to hand-mixed only. Instead, bale wall footings were formed using donated plastic grain sacks. These bags were filled with dirt, tamped, and layed in a running bond up to four feet high, leveling the grade. This packed earth retaining/foundation wall seems stout and we were comfortable with having the weight of the bales bearing on this footing, but the idea of having the roof load added to this seemed a bit much. The bale walls, and their coating of earth stucco now stand almost independently from the other structural elements of the building. We are very impressed with this cheap and stable foundation technique, but look for some cautions in the upcoming article on the construction process.

Poles

A post and beam frame on concrete pier footings supports the weight of the roof structure. While we didn't harvest these 40-50 year old lodgepole pines ourselves from Home Power land, they are still a rather environmentally and economically efficient material. The trees are felled and run through a debarking machine, that's it. The peeled poles display all the structural characteristics of the original tree, except the roots. The six to eight inch in diameter poles were 25% of the cost of milled, 6x6 fir posts and contained about a third of the embodied energy. The guy at the yard made it real clear that he wasn't selling "peeler cores," the

Above: The tower from the North. No access yet.

less-structural leftovers from plywood manufacturing. Trees are a renewable resource if the forest is treated with respect, and these relatively young round poles create little unused byproduct.

Mud

The mud at Agate Flat is deep, sticky, and everywhere. The high clay content makes it stick to everything: tires, boots, animals. After years of experience fighting the effects of the sticky goo Richard and Karen were convinced of its ability to bond into a tough construction quality material. They were also psyched about the karmic implications of making good use out of a previously frustrating element of their remote existence.

Using the mud as a natural, breathable, earth stucco on the strawbales was cheap, easy, and fun. While we are still experimenting with the variations in recipes, the outcome looks good so far. Thanks to Mix-Master Dave, Doug, Suzan, and AJ for their help with the dirty work.

Under Construction

With the appliances and materials defined, construction commenced. Often, manual labor was used to replace fossil fuels, or to access our low-energy materials. Hundreds of stones were brought from the other side of the creek by wheelbarrow. Footings and trenches were dug by hand. When power tools were used they were run on the Home Power RE system. A solar-powered cement mixer mixes our adobe stucco. It feels good to create a relatively luxurious structure while paying attention to the energy resources going into it.

Detours

Throughout this project, and surely still to come, were many changes of plan and, well, mistakes. The windows are a perfect example. Luckily, when Joe found the four huge windows that became our south wall the building was still on paper. The original plans had the bents on four foot centers; the windows were five by eight foot. Back to the drawing board to remove one bent and spread the others to five foot nine inches on center. When building with salvage, we suggest aquiring as many of your materials in advance as you can so that you can design your building around them. Architects don't work that way, but this is homebrew.

Other changes happened on the roof. We had wrestled 18 foot by six to eight inch diameter peeled poles into place as rafters. Only then did we realized that to use more of the same material as purlins would be structural overkill, not to mention difficult. Thousands of needless pounds of material were eliminated from the roof load by switching to dimensional lumber. Left over poles will become future projects.

The plans called for a vaulted ceiling. But when we started crunching numbers for cost we found that externally applied foam board cost three times as much as the equivalent R-value in fiberglass. We opted to create a cold attic space by adding a ceiling of salvage-pile, one by twelve rough-sawn pine, and fiberglass batt insulation. Unfortunately we didn't have time to explore other natural insulation alternatives. Suggestions from readers would be appreciated.

Below: large roof overhangs kept bare bales dry over the winter.

Above: Big Blue, the composting toilet, in the bottom of the Tower of Turd (surrounded by the usual construction clutter.) Vents above the tank allow warm air into the second floor, taking the chill out of winter duties.

The vent on the entire south edge of the ridge peak (and the gable end vents) was added to vent excess summertime heat from the new attic. But this innovative change of plan was actually inspired by a different need. The ridge vent also acts as a chase through which solar water heater plumbing can pass. No holes need to be punched through the roof as different solar hot water systems come and go. The vent is screened to discourage critters, and overlaps to discourage the weather

This new ceiling also needed the ability to vent to the attic. Simply, a row of four ceiling boards near the north wall is hinged. Flip them up and excess heat and moisture can escape to the attic and out.

Also with a ceiling added, the bathing deck needed to be lower to accommodate the shower height. No longer did we have ample below-deck clearance to crawl in and plumb comfortably. So we added the interior retaining wall of dirt bags. Now there is over three feet of headroom below the bathing deck, plumbing access is easy, and we saved ourselves many wheelbarrow loads of back filling.

Lucky for us, we are in charge of the project, with the time and freedom to make changes as we see fit. The balance of planning versus flexibility is up to you when you are doing the project for yourself.

On Schedule?

The project has been under way for over a year now, progressing mostly on weekends between Ben's magazine schedule and Joe's job at Electron Connection. Over that time we have learned a lot, and can finally see a light at the end of the tunnel. The floor is unfinished on the inside. Outside, final layers of stucco will have to wait until spring nights are above freezing. Plumbing and electrical systems are still in the planning stages. Even before the building is finished an addition is planned. On the east end a new power room and electronics workshop will be built...eventually.

A disclaimer. We were excited but aprehensive when it was decided that we would undertake this project using alternative building techniques. The prospect of using low energy, earth friendly, and inexpensive materials to create an efficient structure seemed to fit

Remote Possibilities

Agate Flat is 50 miles from town, over an often treacherous mountain pass, and up 9 miles of rough or muddy jeep road. A round trip drive takes over three hours (chores not included). Needless to say, building in an "out-there" location is a bit of a challenge.

The cost to deliver the strawbales we used for the bathhouse was more than the bales themselves. Dump truck and cement truck drivers will only bring half a load at a time due to the road, yet delivery still costs full price. We couldn't bring ourselves to pay so much for sifted dirt. For many months, before Joe bought a full-size pickup, parts of the project sat half-finished.

In one early project adventure, we drove a 24 foot rental truck 300 miles to Central Oregon, loaded it with forty 22 foot pine poles, and all the huge windows for the project (Logs and glass...together!), back to Agate Flat, off-loaded, then back to town. Slept in the back overnight, picked up metal roofing and a pallet and a half of concrete in the morning, back up to the Flat, off-loaded by hand, then back to town to drop off the truck by 4:00. The 48 hour rental was well worth the money to get that much material up the hill so quickly. They didn't even charge us for the blown tire and hole in the truck floor from picking up a rock while stuck in the creek bed. Whew!

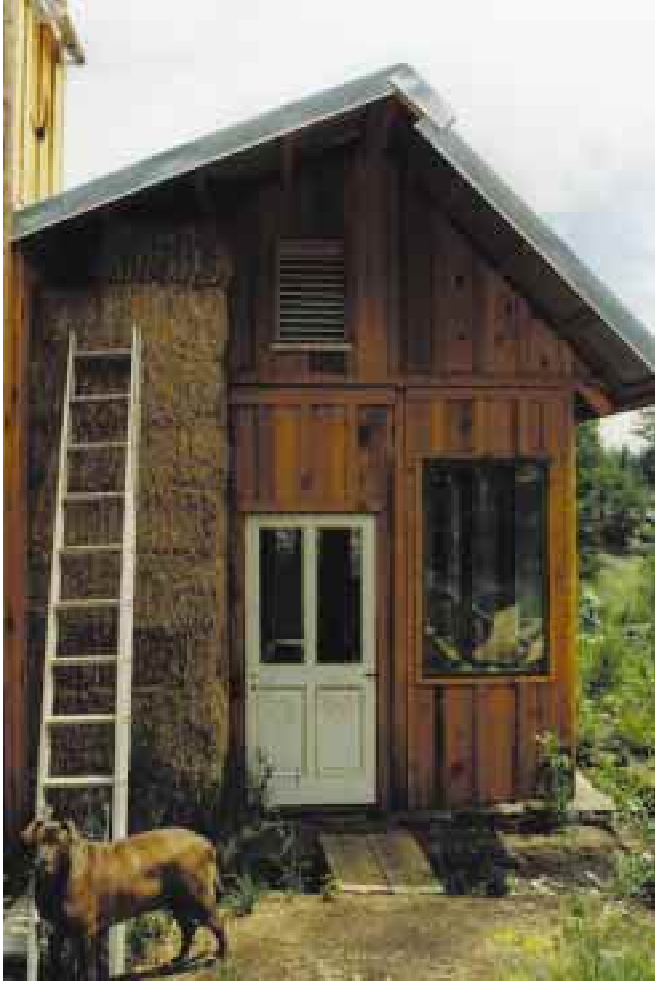
It's also amazing how a single small missing part can grind a whole project to a halt. One screw, gas line fitting, water line fitting, bolt, bag of concrete, spade connector, drill bit, or other gizmatchi can put the kabash on a whole day's work.

We've come up with three methods to help combat the missing part blues:

1 **Plan as much as possible.** If you try to figure it all out in advance, you might have it mostly figured out once the work gets going.

2 **Buy extra.** Plan for dropping little parts from the top of the ladder. Plan for poor planning (see #1). Build yourself a stockpile of often used bits and pieces.

3 **Be patient.** Remember, it's usually better to wait for the proper part to get the job done right. Don't rush, bailing wire and duct tape are for experienced professionals only.



Above: Brown the dog at the west entrance.

Home Power's ideals perfectly. However, Joe was the only person with building experience on the crew, and his expertise lies in more traditional carpentry. This article and the one to follow describes the techniques we used, and our reasoning, in the building of the bathhouse. Many of the techniques are brand new to us, and in our eyes still experimental. Please use our experiences to generate ideas, but see the following list of references for more in-depth information on these building techniques. These are the resources that we used.

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Access

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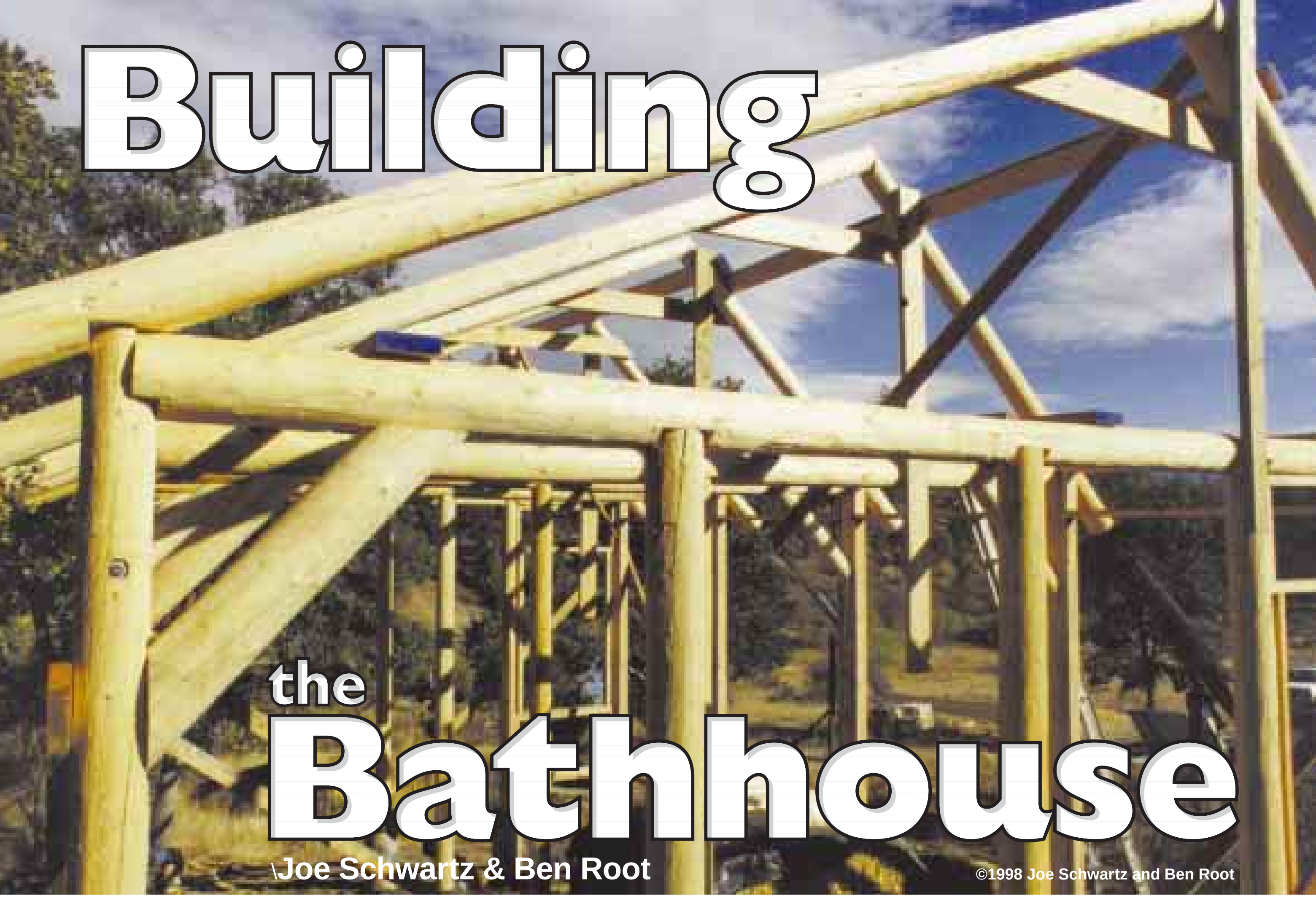
Thanks to *Man or Astro-Man?* for aural stimulation throughout this project. www.astroman.com



Building the Bathhouse

\Joe Schwartz & Ben Root

For over twenty years Home Power has served as a test bed for renewable energy (RE) system hardware. The sheer volume of RE components living up on Agate Flat is a testament to this. Ancient PVs are still contributing to daily power production, worn out wind generators and electronics inhabit scrap piles and are up for grabs as spare parts, and untested gear waits its turn in outbuildings or under numerous blue tarps. While this scene would be expected by *Home Power* readers, another look around the property reveals experimentation in a wholly different direction.

In 1970, Richard, Karen, and friends built a 26 foot diameter wooden, two frequency, octahedral dome based on designs from Stewart Brand's original *Dome Book*. It was built with hand tools and took only thirteen days to complete. The dome had a dirt floor, no foundation, no insulation, and a roof that kept the rain out more often than not. It was also the first structure on the Flat where hay bales were used for something other than livestock feed–furniture! In 1973, The Pod, a 15 foot 8 inch diameter, twelve-sided stressed plywood structure on a six foot high platform was built. The dome became the hay barn, which isn't the most efficient space in which to buck and stack hay! An old tipi platform in the pine grove is now a nice place to sit and stretch. Currently, Home Power Central is housed in the Plywood Palace, which utilizes rough sawn fir in its more conventional construction.

When word came 'round that Richard and Karen were ready to build a bathing facility, we were stoked to try some low-impact building systems including straw bale wall construction, now experiencing a revival. Since we weren't the ones dropping the cash on the project, we approached them somewhat tentatively with our ideas. Richard was grinning when he said, "Take a look at this place! It's always been experimental."

Right off the bat we'd like to share two insights after working on the bath house project for a little over a year. First, straw bale construction is a somewhat less technical building method for the inexperienced owner/builder. But construction experience is still required, especially when the roof and finish details come into play. Second, ecological implications aside, don't plan on saving piles of money by building with bales. Wall construction typically accounts for only about 10% of a structure's overall cost. Even if we assume that we can complete straw bale walls for half the cost of a standard 2 by 6 stick frame, the materials and labor expenses saved is still only 5% of the total building cost. This isn't to say that construction costs can't be brought way down on a given structure, but utilizing straw bales only accounts for a portion of these savings.

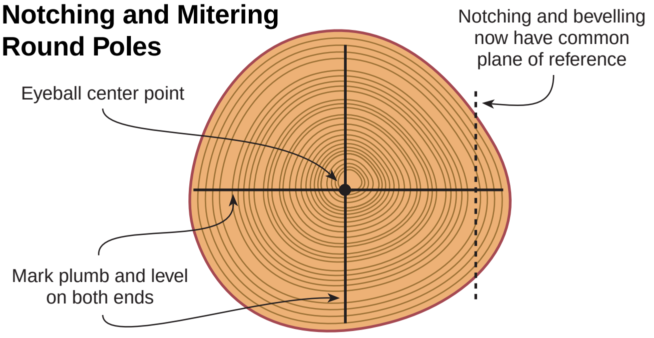
Above: Joe notches beams.

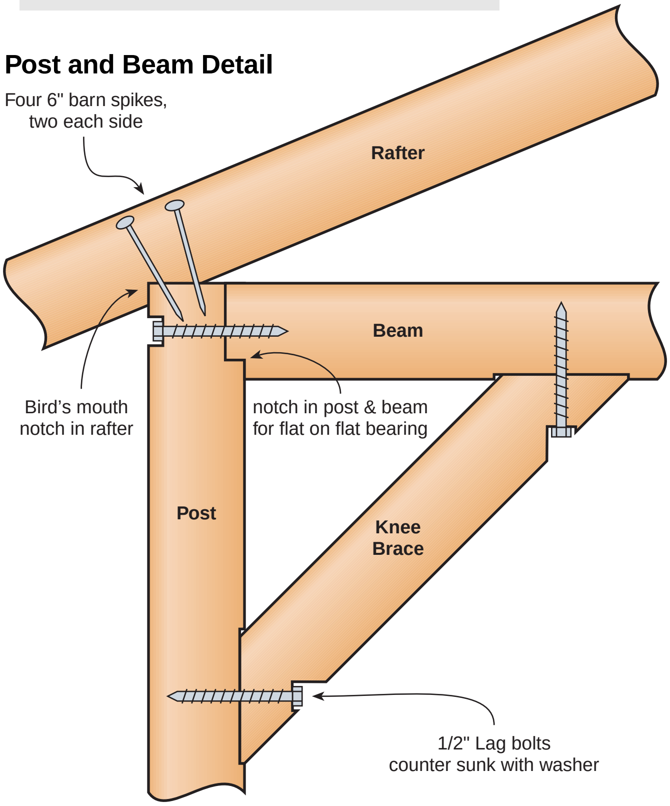
Off the Ground

In the U.S. one of the least expensive and most commonly used methods of outbuilding construction utilizes posts set on independent pier footings rather than a continuous footing. Concrete foundations have a monstrous embodied energy value and aren't cheap. If built right, pole structures can save you a substantial amount of money before the project is even off the ground, so to speak. For the bathhouse project we opted to utilize this post and pier technique to support the roof load, keeping the straw bale walls non-load bearing. The building was laid out and post holes were hand dug 2 feet deep and 18 inches wide. Agate Flat has a very stable clay based soil and a frost depth of 12 to 18 inches, so these specifications were appropriate. Make sure to research frost depths and soil types in your region prior to pouring footings as requirements will vary. Case in point: when we utilized the same footing method in northern Vermont, post holes needed to be a full 4 feet deep to get safely below frost level. Needless to say we were happy to be digging in southern Oregon. To get the piers above grade we used 12 inch diameter cardboard forms often referred to as Sona tubes, the trade name of one form manufacturer. The tubes were suspended approximately 8 inches above the bottom of the holes. This allowed the hand mixed cement to flow out the bottom of the tubes to

Above: Twelve inch concrete piers extend below frost line. Rebar prevents lateral movement of posts.

Notching and Mitering Round Poles





Above: Posts and beams still spotted with stucco.

create an 18 wide by 8 inch deep footing for the 12 inch diameter concrete columns to bear on, distributing the building's weight. Rebar was used to reinforce each individual footing as well as to tie the piers together above grade, forming a rigid foundation grid.

Framing

The frame of the bathhouse rests on these piers. We recycled asphalt roofing from the original dome to use as a moisture barrier between the posts and concrete, which can wick water. The poles were 6 to 8 inch diameter peeled Lodgepole pine which generally grow straight-as-straight. However, compared to working with dimensional lumber, pole work is more labor intensive. The frame of the building still went up in about a week, or 80 hours of total labor.

Post heights were calculated by shooting the relative height of each individual pier and correcting for the total wall height. Posts were squared off with a chainsaw and dialed in with a hand held Makita power planer and a framing square. Since our skill with a chainsaw was limited to cutting firewood, the planer proved to be an indispensable tool for squaring up our cuts. The bottom of the posts were drilled out and tightly fit over 4 inch, #4 rebar anchors that had been set in the concrete piers during the pour. These anchors protect the posts against lateral movement with the weight of the building doing the rest.

No sophisticated scribing was used in the frame joinery. Our technique was very similar to building a really tall post and rail fence. Notches were cut into the posts and connecting beams with a Skil saw and evened up with sharp chisels. The notching allowed for the bearing of

Below: Ben cleans up a notch in a beam.

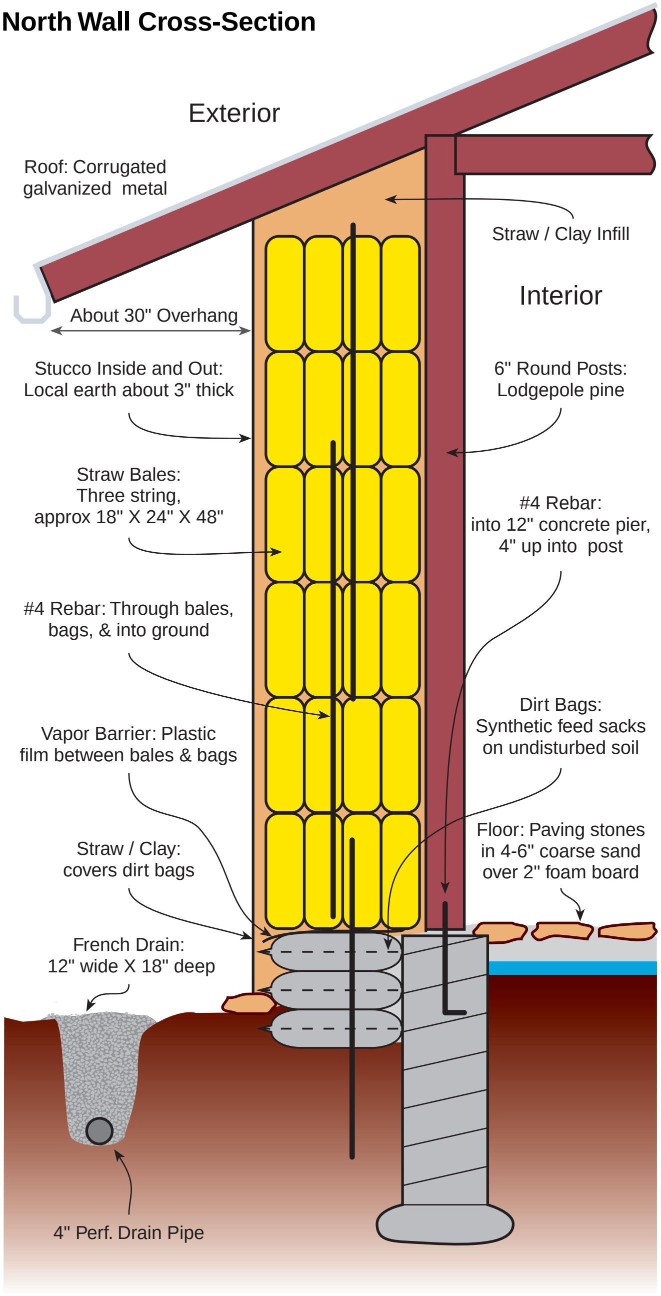
each beam to be directly over corresponding posts and therefore directly over the concrete footings. The five individual bents were plumbed up and then held square with 3 foot knee braces angle cut to 45 degrees.

Above: The east end shows dirt bag, stone, and straw bale techniques.

Things got much more complicated when we began roof framing. The roundness of the building material added to the complexity and construction time. The trick was getting the plumb cut at the top of the rafters on the same plane as the birds mouth on the bottom. We secured each framing member to a set of saw horses and drew corresponding plumb and level reference lines on both ends of the pole. Now we could rotate or spin the poles in any direction, as required to make cuts, and still come back to a definite position to mark out the next cut. We devised an elaborate series of jigs that allowed us to make our initial chainsaw cuts which were then cleaned up with the power planer and hand chisels.

We became meticulous when making these measurements and cuts since positioning the 18 foot rafters on the roof was an effort that necessitated much gruntin' and groanin'. We sure didn't want to do it twice! The north roof pitch was set at 5/12 to match the neighboring framed building. The south roof was set at 12/12, or 45°, which on Agate Flat is close to the optimal angle for solar thermal collectors. Dimensional 2 by 4 inch purlins were notched in place which was also a trick considering the variations in rafter diameter. New galvanized metal roofing was applied because of its low price and durability, creating a full-on straight roof line.

North Wall Cross-Section



Dirt Bags

With the building's frame and roof load supported, we began building a footing to carry the weight of the bale walls. The grade at our site dropped off 4 feet over the building's length and we wanted to build up the footing level. As a result there would be no need to step the bale wall and deal with the vagaries of bale dimensions. Hinterland Llama Ranch in Sisters, Oregon hooked us up with 200 plastic feed sacks for the construction of the wall footing. From then on we began, and continue proudly, to refer to ourselves as "Dirt Bags."

To control water runoff around the building perimeter, we laid 4 inch perforated pipe and gravel in a French drain that was hand dug around the north, west, and south walls. The grain sacks were filled with dirt from this perimeter drain, laid in a running bond, and compacted by much jumping-up-and-down on each

Above: Driving the rebar which pins bales together.

course. They were finally pinned to each other and the ground with lengths of rebar. These flexible bags of dirt were amazingly self leveling. We also found that we could easily correct the level of each course by adding or removing dirt from individual sacks. The open ends were merely tucked under before the next bag was snugged in place. The dirt bags proved to be an inexpensive, fast, and forgiving construction material and created a bomber base for the bales.

A word of caution. When we picked up the grain sacks our friend Danny at the ranch warned us to keep the bags out of the sun. After the footing was built, covering it somehow got put on the 'round-to-it list and never happened. We experienced significant photo-degradation on the east footing within six months, and now must do some repairs. So keep the sacks out of the sun!

The wall footings were completed by building the south and southeast retaining wall with local stone. Basalt gathered from a nearby cut along the creek bed was built in to a rustic but beautiful front wall. Only the cap stones were mortared to prevent weathering.

Straw Bale

Straw bale walls go up fast. We had them up and secured in a day. We still laugh about how little the bales actually have to do with a straw bale building. Building with bales requires few tools and the bales themselves are a relatively intuitive material to build with. The speed the walls went up was due to where we chose to use straw bales. All building materials display characteristics which make them more efficient under certain circumstances than others, and straw bales are no exception. Ben's building design specified bales only where their dimensions seemed appropriate.

To capture solar gain for space heating and plant growth, the building's south wall is mainly glass with posts to support the roof load. Entrance doors and a pair of small windows are located along the south eight feet of both the east and west walls. This layout eliminated the variables inherent in floating window casings in bale walls, as well as the time consuming job of cutting and retying bales to custom dimensions. In addition, the dirt bag footing was laid along the outside of the building posts, so there was no time spent fitting the bales, or the footing for that matter, around the posts. Bales enclose the entire north wall of the building and wrap around half of the east and west walls. These wall segments have no windows or obstacles to work

Below: Dave sifts the good stuff.

around. The bales were laid in a running bond just like the dirt bags and pinned with overlapping lengths of rebar. To keep them from bowing out from the frame, each course was tied to the posts as the wall was built. This technique created a structural tie between the bales and the building's frame while still allowing the bale walls to settle. We were working with 10 foot pieces of rebar so the roofing needed to be left off until the bale walls were built, allowing adequate clearance for driving the rebar.

The bale walls remained without stucco through the winter of 1996/97 while we completed a mud room and pantry project for the current Home Power cabin. We watched the straw bale walls closely over the winter. As the rain fell and the snow piled up, the large overhangs kept the bales dry. The dirt bag footing and French drain kept the base of the bales well above grade and away from any water runoff. If you're building in a climate where precipitation is moderate to heavy, make sure to give ample thought to these elements of building design. Our bale walls never got wet except in seriously driving rain. Remember, straw bales are not a forgiving building material when excessive moisture is an issue.

Above: Mix-Master Dave spins the hits
The solar-powered mud machine saved much labor.

Stucco and Cob

We began applying stucco last fall after giving the bale walls nine months to settle. For 200 bucks we found an old cement mixer with a 4.2 amp, 117 vac motor from a junked washing machine. It worked flawlessly, cut down the time involved in the stucco process by an easy 50%, saved all our backs, and gave Mix Master Dave time to flip CDs every couple of batches. It's an enlightening sight to watch a cement mixer hard at work, running off nothing but sunshine!

We began applying stucco just in time for the cold weather to start creeping in. The nights were still above freezing but we took to heating pots of water on the woodstove, adding it to the mix to make the mud temperature tolerable on our hands.

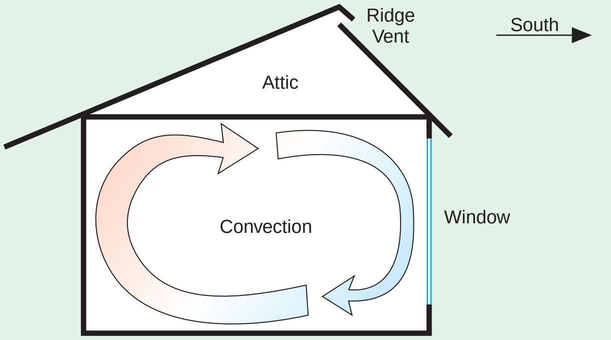
We heard that chicken wire wasn't necessary unless synthetic stucco was used over foam board. After a bunch of back and forth we decided to use chicken wire as a stucco mesh anyway, figuring the more strength the better. After the first batch of mud our hands were thoroughly shredded by the chicken wire. Trowels didn't work either as the corners constantly got hung up in the wire. So, off with the chicken wire and on with the mud, which stuck wonderfully to the rough bale surface!

Our interior and exterior stucco finishes have four distinct layers, each with a different earth-sand-water ratio. The soil on Agate Flat has a high clay content, so our different mixes were always based on adding varying amounts of sand. Our stucco seemed to work out like this: more sand = less cracking = harder to apply. No sand was added to our first layer as we

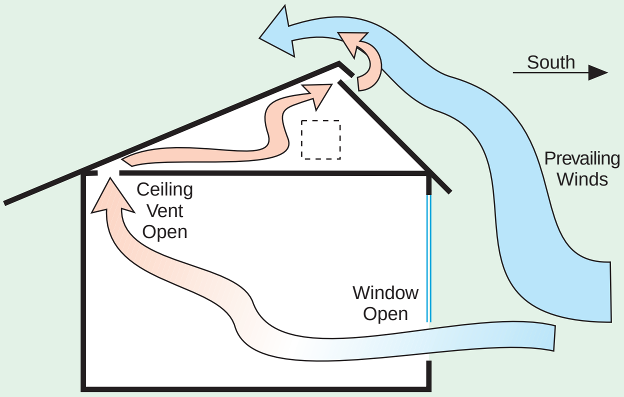
Below: Joe and Doug spread the first thin layer of stucco.

Bath House Ventilation

As mentioned in the previous article, this building is not a living space. The excessive glass necessary for the garden bed makes larger temperature fluctuations possible. While the southern roof overhang will help prevent overheating in the summer, we designed a ventilation system to help fine tune interior temperatures. The top diagram shows air movement during a typical heating cycle. Sun shining through the south windows heats the air and floor mass of the building. Rising hot air would tend to stratify, but cooling along the glass face causes a convection cycle as shown.



In the second diagram the lower portion of the south windows are opened to catch the prevailing winds. Also, vents in the ceiling along the north wall are opened. A chimney effect is created with air flow travelling through the building and into the attic space. There, the air can either escape through the ridge vent or out two vents in the gable ends. Adding vents on the north side of the ridge could have taken advantage of the low pressure on the leeward side of the roof by drawing air from the attic, but we felt that the current design is adequate. The west end vent is merely louvered while the east end contains a Sol-Aire 24 Volt DC fan. Except for experimentation during the stucco drying process, we have not yet had to open the ceiling vents…but summer is coming.



wanted it to be as sticky as possible to create a positive bond between the straw and the successive stucco layers. Water was added until it was the consistency of a cream soup enabling us to work the mix deep into the bales with our hands. For the second coat about 25% sand was added to the mix along with several large handfuls of chopped straw to add tensile strength to the stucco. Thanks to Bob-O for loaning us his chipper to chop straw. It was mixed thick like pudding and we were able to get a 1 to 1 1/2 inch layer on the walls. Between the second and third layers, clay with cob and straw was used to fill low spots and gaps between bales and along the gable ends. The third layer consisted of the same earth-sand ratio without the straw, adding another 1 inch to the walls. The finish layer was a mix of 50% sand and 50% earth and was the only layer we ran a trowel over for a rough finish. The multiple layering system gave us about 3 inches each of interior and exterior stucco that set up nearly as hard as cement.

Initially, we had been concerned about the perfect stucco mix. We found, however, that trial and error quickly led us to the right recipes. Thicker was easier to spread though harder to get out of the mixer. Sandier prevented cracking but didn’t stick as easily to the layer beneath, and was rougher on the hands. We suggest that you just experiment. Besides, it’s fun…really!

Using earth stucco on straw bale walls is a dynamic process as both temperature and humidity radically affect the building material during application and drying. As our second layer set up, we began to notice some surface mold growing on the straw we had added to the mix. None of us had any experience working with stucco, synthetic or otherwise, and none of the books we read or people we spoke to mentioned anything about mold during the drying process. Admittedly, we freaked a little. The more we thought about it the more we were convinced that mold spores were likely to be present in straw and that water was going to wake ‘em up like a strong cup of coffee. Barring rampant herbicide application, this was accepted as part of the process.

Close inspection revealed that the mold only occurred where the straw was exposed to air and as soon as the layer dried the mold died off. In addition, the bales themselves were completely dry so outside water infiltration was eliminated from the figurin’. We also found that the walls inside were experiencing more mold than the outside, presumably due to higher humidity, higher temperatures, and less air circulation than outside. The humidity inside the building was as high as 90% from all the moisture introduced by the wet stucco. Our first reaction was to dry the walls out and

Materials Costs

Location	*Material*	*Cost*	*%*
Foundation	Drain pipe	$35.00	1%
	Feed bags	$0.00	0%
	Sona tubes	$125.00	2%
	Redi mix	$221.00	4%
	Rebar	$68.00	1%
	Rigid insulation	$131.00	2%
	Mortar mix	$25.00	1%
	6 Mil. plastic	$38.00	1%
Framing	Lodgepole	$576.00	10%
	Dimentional	$574.00	10%
Decking	Cedar	$163.00	3%
Siding	Pine	$931.00	16%
	Straw bales	$590.00	10%
Stain	Pine	$144.00	2%
Roofing	Galv metal	$640.00	11%
	Felt paper	$59.00	1%
Doors	Salvage	$135.00	2%
Windows	Salvage	$348.00	6%
Hardware	Misc.	$550.00	9%
Insulation	Fiberglass	$252.00	4%
Truck Rental		$223.00	4%
	Total	$5,828.00	
	Cost / Sq. Foot	$16.00	

deprive the mold of all necessary moisture. So we fired up the woodstove good and hot to force dry the walls. They cracked rather severely! Oh geez…

For the next layer we opened up the building to full ventilation mode. While this increased circulation for drying, it also made for one cold work space. We finally dialed in our climate control by closing the building, keeping the stove temperature down, and regulating the temperature to 65°. Humidity dropped to around 60% and we were in business.

The other wall areas of the building, above and below windows and doors, were framed with conventional lumber and insulated with fiberglass. They were sided with 1 by 12 pine board and batten. The natural materials; straw, stone, and wood; while rustic, play off each other in a beautiful way. Metal roofing, steel cable railings, and glass add just a touch of tech.

For What It's Worth

Our monetary goal was to keep the materials cost of the bathhouse under $20 a sq. ft and we came in at a respectable $16. We trimmed money off the project by not using excavation equipment (other than shovels), tons of concrete, or too much milled lumber. We saved some money by using straw bales, dirt bags, and recycled lumber. We saved piles of money by using salvaged windows and doors.

Above: The Turd Tower with obligatory moon window. The small PV powers the toilet's vent fan.

See the Letters section for some interesting feedback from readers about the bath house project.

Access

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